PROBIOTIC VIABILITY AND SENSORY PROPERTIES OF ICE-CREAM SUPPLEMENTED WITH ENCAPSULATED *Lactobacillus bulgaricus*

NURZYYATI BINTI MOHD NOOR

UNIVERSITI TEKNOLOGI MALAYSIA

PROBIOTIC VIABILITY AND SENSORY PROPERTIES OF ICE-CREAM SUPPLEMENTED WITH ENCAPSULATED *Lactobacillus bulgaricus*

NURZYYATI BINTI MOHD NOOR

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Bioprocess)

Faculty of Chemical Engineering
Universiti Teknologi Malaysia

MAY 2013

To my beloved mak, abah, siblings and best friends; thank you for constant encouragement, understanding and motivational support.

ACKNOWLEDGEMENT

I am grateful to Allah S.W.T that I could finish this thesis. I wish to thank to all those whom directly and indirectly had helped in making this research a success:

Prof. Madya Dr Ida Idayu Muhamad for her advices, support, and guidance throughout this work

Professor Ramlan Abd Aziz, and Professor Dr. Mohamad Roji bin Sarmidi of Institute of Bioproduct Development (IBD), Universiti Teknologi Malaysia for making the research facilities available.

Hjh. Huzaimah, Hj. Mohd Noor, Aisyah Anuar, Zuhaili Idham, Nur Zafirah, Nur Zuhairah, Pn Nor Zalina, Solleh, Norliyana, En Ayub, Puan Muna and all the staff in the Institute of Bioproduct Development (IBD) for all their time and effort.

And my fellow research students of Engineering Department for their help and useful discussion.

ABSTRACT

The aim of the research is to study the encapsulation method that being used to protect probiotic bacteria *Lactobacillus bulgaricus (Lb)* in ice cream for a period of 90 days of storage at -20 ˚C. Three different formulations have been developed i.e. Formulation A (FA, mixtures with gelatin 0.1%), Formulation B (FB, mixtures with gelatin 0.3%) and Formulation C (FC, mixtures with gelatin 0.5%). All statistical analysis has been reported at $p<0.05$. It was found that the microencapsulation or coating of *L.bulgaricus* significantly influenced their survivality compared to uncoated probiotic. Formulation B with coated *Lb* (FB.3) showed the highest viability which achieved $10^{8.34}$ cfu/g. FB.3 showed the best outcome in terms of the quality factor measurements i.e. dry matter, fat, moisture content, viscosity which are 34.50 ± 0.89%, 7.66 ± 0.07%, 65.50 ± 0.89%, 125,000 ± 0.00 mPa.s respectively, and the size range of beads from 0.8 to 1.0 mm within the accepted level. At the end of 90 days storage at -20˚C, the viability of the coated cells in formulation B are still within the accepted level with 2.2 x 10^8 cfu/g population which remained above 10^6 cfu/g. There are significant increase in viscosity with increased gelatin levels similarly with moisture content. Meanwhile dry matter significantly reduced in coated probiotic compared to uncoated in all of the ice-cream samples but protein showed remarkable reduction in FA and FB only. Sample FB showed significant reduction ($p<0.05$) on melting rate and viscosity. The highest fat content in FB gave the highest viability as compared to FA and FC. From the sensory evaluation towards probiotic flavour and acidic flavour, the overall panel rank for the highest acceptance is in Formulation A with coated *Lb* (FA.3) as compared to uncoated probiotic ice-cream i.e Formulation A with uncoated *Lb* (FA.2); Formulation B with uncoated *Lb* (FB.2) and Formulation B with coated *Lb* (FB.3). Furthermore, there are significant differences ($p<0.05$) between non probiotic ice-cream and probiotic ice-cream for all sample in terms of probiotic flavour and acidic flavour. Based on defined cooked flavour, probiotic flavour, and acidic flavour, there was a remarkable overall acceptance on the ice cream with coated probiotic. Meanwhile, acceptance upon uniformity of the ice cream based on colour and appearance showed more variation among the sensory panels. It can be concluded that the microencapsulation had good effect on sensorial acceptability ($p>0.05$) of probiotic ice cream. The results indicate that dairy ice cream can be considered a suitable vehicle for incorporating coated probiotic microorganisms for higher survival and better sensorial acceptance.

ABSTRAK

Tujuan penyelidikan ini adalah untuk membangun kaedah pengkapsulan untuk melindungi bakteria probiotik *Lactobacillus bulgaricus (Lb)* dalam ais krim sepanjang tempoh 90 hari penyimpanan pada suhu -20 ˚C. Terdapat tiga formulasi yang dibangunkan iaitu Formulasi A (FA, campuran gelatin 0.1%), Formulasi B (FB, campuran gelatin 0.3%) dan Formulasi C (FC, campuran gelatin 0.5%). Keseluruhan analisis statistik diperolehi adalah pada $p<0.05$. Didapati kebolehidupan *L.bulgaricus* yang dikapsulkan adalah signifikan berbanding dengan yang tidak dikapsulkan. Formulasi B yang mengandungi *Lb* yang dikapsulkan (FB.3) menunjukkan kebolehidupan paling tinggi dengan mencapai $10^{8.34}$ cfu/g. FB.3 menunjukkan hasil yang terbaik terhadap pengukuran faktor kualitinya iaitu bahan kering, lemak, kandungan kelembapan dan kelikatan masing-masing adalah 34.50 ± 0.89%, 7.66 ± 0.07%, 65.50 ± 0.89%, dan 125,000 ± 0.00 mPa.s, manakala julat saiz butiran kapsul pada anggaran 0.8 hingga 1.0 mm dalam lingkungan nilai yang boleh diterima. Pada akhir tempoh penyimpanan selama 90 hari pada suhu -20˚C, kebolehidupan sel formulasi B yang dikapsulkan masih dalam tahap yang diterima pada 2.2 x 10^8cfu/g sel iaitu melebihi 10^6 cfu/g. Peningkatan yang signifikan berlaku ke atas kelikatan dengan penambahan kuantiti gelatin, begitu juga terhadap kandungan kelembapan. Sementara itu, peratus bahan kering menurun secara ketara dalam probiotik yang dikapsulkan berbanding dengan tanpa-kapsul di dalam semua sampel ais krim manakala nilai protein menunjukkan penurunan dalam FA dan FB sahaja. Sampel FB pula menunjukkan penurunan yang signifikan ($p<0.05$) ke atas kadar kecairan dan kelikatan. Kandungan lemak yang paling tinggi dalam FB memberikan kebolehidupan paling tinggi berbanding dengan FA dan FC. Hasil penilaian sensori terhadap perisa probiotik dan rasa masam mendapati penerimaan tertinggi keseluruhan panel pada Formulasi A yang mengandungi *Lb* yang dikapsulkan (FA.3) berbanding dengan ais krim probiotik yang tidak dikapsulkan iaitu Formulasi A yang mengandungi *Lb* yang tidak dikapsulkan (FA.2); Formulasi B yang mengandungi *Lb* yang tidak dikapsulkan (FB.2) dan Formulasi B yang mengandungi *Lb* yang dikapsulkan (FB.3). Tambahan pula terdapat perbezaan yang signifikan ($p<0.05$) terhadap perisa probiotik dan rasa masam bagi semua sampel di antara ais krim tanpa probiotik dengan ais krim berprobiotik. Berdasarkan ketentuan rasa-dimasak, perisa probiotik dan rasa masam, ais krim mengandungi probiotik yang dikapsulkan mendapat penerimaan yang tinggi secara keseluruhannya. Sementara itu, penerimaan terhadap keseragaman ais krim bagi sifat warna dan rupa luar menunjukkan pelbagai variasi di kalangan panel. Kesimpulannya, mikrokapsulan memberi kesan yang baik terhadap penerimaan penilaian sensori ($p>0.05$) ke atas ais krim berprobiotik. Hasil kajian menunjukkan ais krim sesuai digunakan sebagai sumber untuk bakteria probiotik yang dikapsulkan memperolehi kadar kebolehidupan yang tinggi dan penerimaan sensori yang lebih baik.